THE OSCILLOGRAPHER

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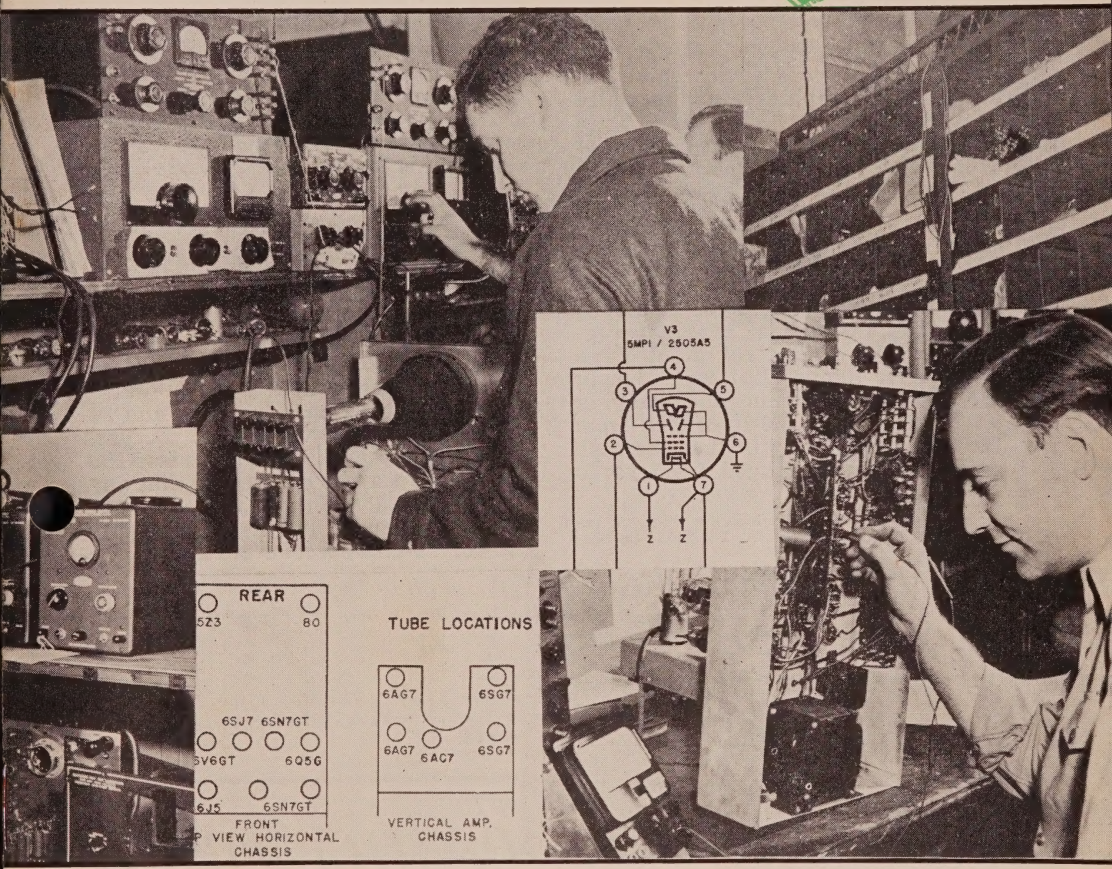

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THE DU MONT TYPE 256-D CATHODE-RAY OSCILLOGRAPH

by

Melvin B. Kline*

General

The Du Mont Type 256-D Cathode-ray Oscillograph is a wide-band precision oscillograph designed for pulse applications. It consists of a Type 5CP-A Cathode-ray Tube operated at 4000 volts total accelerating potential, driven sweeps of fixed duration which may be triggered from an external source or from an internal trigger generator, a precision variable delay circuit, timing marker generators, and a wide-band amplifier. This instrument is a commercial version of the Du Mont Type 256-B A/R Range Unit used during the war as a precision radar ranging unit. The Type 256-D differs from the Type 256-B only in that the base scale has been changed from yards to microseconds and that commercial components have been substituted for certain service-specified components without sacrificing quality or performance. A block diagram of the Type 256-D Cathode-ray Oscillograph is shown in Figure 2.

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Sweeps

There are two types of sweeps in the Type 256-D Cathode-ray Oscillograph, identified as A (undelayed)- and R (delayed)-sweeps. The A-sweeps have durations of approximately 4, 10, 25, 100, 1000 and 4500 microseconds (for a 4-inch sweep length). The R-sweeps have durations of approximately 4, 10, and 25 microseconds. By means of the precision delay circuit, the start of the R-sweeps may be delayed so that any 4, 10, or 25 microsecond portion of the 100 microsecond A-sweep or any 10- or 25-microsecond portion of the

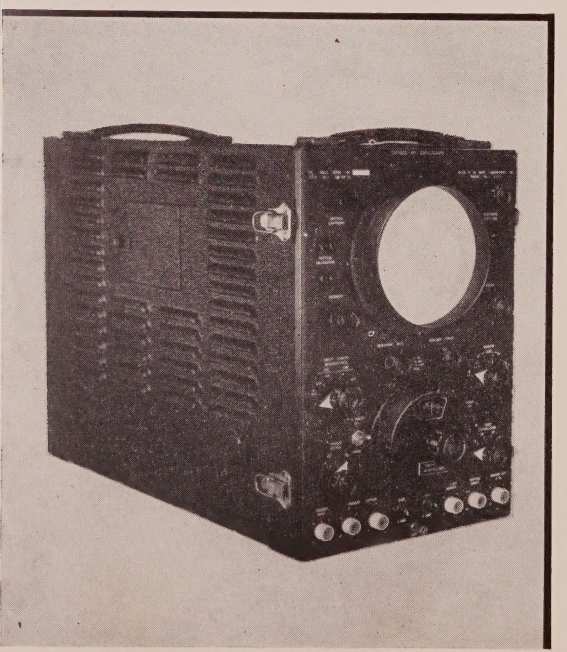

Figure 1 — The Du Mont Type 256-D Cathode-ray Oscillograph.

THE OSCILLOGRAPHER

The purpose of this publication is to provide information on new developments and applications of the cathode-ray oscillograph and related apparatus.

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Joseph Pastor, Jr. - Editor
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1000-microsecond A-sweep may be expanded and examined closely. The 4500-microsecond A-sweep is used to observe complete duty cycle* operations at repetition rates of 300 times/sec and above.

The start of these R-sweeps is accurate to within ±0.1% of full scale of the delay range used and may be read directly on a calibrated dial.

By means of the calibrated sweep-delay dial, therefore, the exact time relationship of any signal appearing on one of the A-sweeps with respect to the main trigger may be accurately measured within ±0.1 microsecond on the 100 microsecond scale or within ±1 microsecond on the 1000 microsecond scale. The sweeps are not calibrated, and any nonlinearity of the sweep does not affect the dial reading.

The sweeps may be triggered from the internal trigger generator which has a continuously variable repetition rate of 80 to 2000 times per second for the 100-microsecond scale, and 80 to 400 times per second for the 1000-and 4500-microsecond scales. External triggers of either polarity with repetition rates of 0 to 2000 times per second for the 100- microsecond scale and 0 to 400 for the 1000- and 4500-microsecond scales may be used to trigger the sweeps. A trigger input signal of ±15 volts with a rate-of-rise of 100 volts/microsecond is necessary for accurate triggering. Triggering signals with a rate-of-rise as low as 10 volts per microsecond will trigger the sweep, but accuracy of the dial reading will be impaired unless recalibrated. The internal trigger-pulse is available at output terminals to allow triggering of other apparatus by the Type 256-D. A trigger output of 100 volts (positive or negative) is available with a rise time of 0.3 micro-

*Duty cycle (in percentage) is defined as the product of pulse duration in seconds and repetition frequency times 100. Unless the duty cycle is 100 per cent, the complete sequence of operation cannot be seen. In particular, the phenomena occurring just before the start of the trigger or sweep are not shown. Sometimes information in this region is of importance.

The 4500-microsecond sweep therefore allows a second trigger to be seen approximately two-thirds of the way along the sweep at repetition rates of 300 times/sec. This permits observation of the complete duty cycle, and of phenomena occurring just before the trigger occurs.

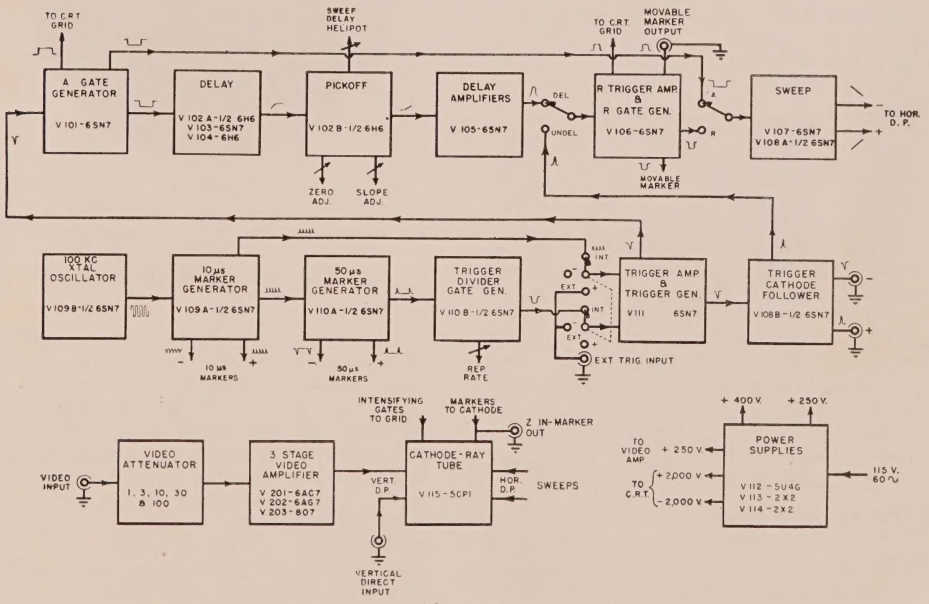


Figure 2

Block Diagram of the Du Mont Type 256-D Cathode-ray Oscillograph.

second, a duration of 1 microsecond, and a repetition rate the same as that of the sweep trigger.

Crystal-controlled timing markers of 10- and 50-microsecond duration and of either polarity are available when internal triggering is used. The timing marks have a rise time of 0.25 microsecond, a duration of 1 microsecond, and an accuracy of ±0.02 per cent. A movable marker, the start of which is coincident with the start of the delay, and whose duration is approximately 25 microseconds, is also available to locate the portion of the A-sweep that is expanded on one of the R-sweeps. These markers are ordinarily available as intensity markers on the sweep, but may be supplied to other apparatus through an output terminal. External intensity-modulation (Z-axis) signals may be fed into the Type 256-D through this same terminal.

Video Amplifier

The video amplifier consists of a three-stage, compensated wide-band amplifier providing a deflection factor better than 0.3 rms volt/inch. It is preceded by a stepped R-C compensated attenuator having ratios of 1:1, 3:1, 10:1, 30:1, and 100:1 instead of a variable gain control. The input impedance of the amplifier is one megohm in parallel with 20 $\mu\mu$f.

The amplifier response is down not more than three decibels at 8 megacycles and six decibels at 11 megacycles. Its low rate of fall permits use up to 30 megacycles. The pulse response is such that the sum of the rise and fall times of a one-microsecond pulse with rise and fall times of 0.01 microsecond does not exceed 0.08 microsecond when passed through the video amplifier. The low-frequency response is such that a 1000-microsecond pulse does not change the vertical position of the base line after the pulse by more than 10 per cent of the base height.

Physical Characteristics

The Type 256-D operates from a 115-volt, 60-cycle power source and is rated at 220 watts. The instrument is 16¼ inches high, 11⅜ inches wide, 26 inches deep, and weighs 104 pounds. The panel has white markings on a black background and the cabinet is finished in black wrinkle. A front panel cover which protects the controls also serves as a container for the instruction manual and the power cord.

The extension ring mounted in front of the cathode-ray tube accommodates the Du Mont Type 271-A Oscillograph-record Camera. A calibrated scale is furnished with the instrument.

Applications

The measurement of pulse waveforms is quickly and accurately accomplished with the Type 256-D Cathode-ray Oscillograph. Pulse rise times and durations can be measured to an accuracy of better than ±0.02 microsecond by means of the calibrated delay dial. It is possible to measure rise time and pulse duration either at the base (10 per cent amplitude) or peak (90 per cent amplitude) of the pulse with excellent accuracy. Although the sweep-delay dial is calibrated to within ±0.1 per cent of the maximum range in absolute accuracy, the accuracy of small difference readings is inherently better. Since ±0.1 per cent represents one dial division, and readings can be interpolated into about five parts, it is therefore possible to make read-

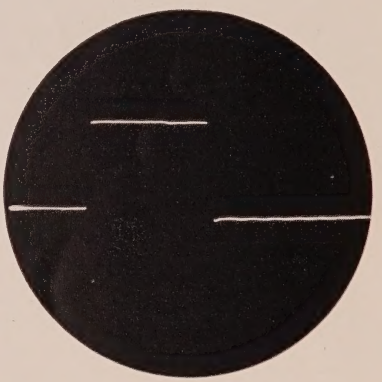


Figure 3
A One-microsecond Pulse, with a Rise Time of 0.02 *μsec, after Passing Through the Video Amplifier of the Type* 256-D *Oscillograph* (4 *μsec R-sweep*)

ings to ±0.02 microsecond.

Figure 3 shows a one-microsecond pulse having a rise time of 0.02 microsecond as seen after passing through the video amplifier of the Type 256-D using the 4-microsecond R-sweep.

Cable testing by the pulse reflection method may also be done with the Type 256-D*. The initial pulse is used to trigger the sweep of the Type 256-D and the time to the reflected pulse is measured with the delay dial.

Another very important use, and one for which the circuits were originally designed (the afore-mentioned Type 256-B) is as a radar ranging unit. By means of this unit the range accuracy of many existing radar units may be increased from ±2 or 3 per cent to ±0.1 per cent (±20 yards on a 20,000-yard range scale). For convenience in using this instrument in radar ranging, a conversion chart (Figure 4) of microseconds to yards is furnished.

*See: Mansberg, H., "A High-voltage, High-speed Oscillograph," Oscillographer, Vol. 9, No. 1, (Jan.-Feb., 1947), page 2.

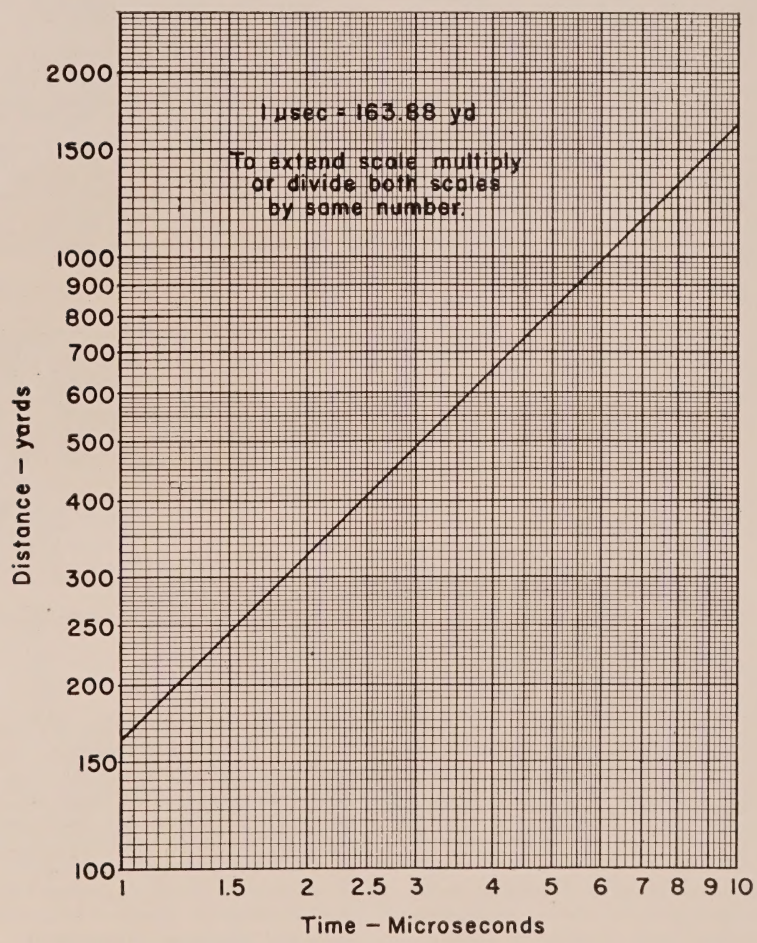


Figure 4
Conversion Chart (microseconds to yards) to Facilitate Radar-Ranging Use.

This chart may be extended for any time-indication by multiplying or dividing both scales by the same number. For example, to convert 1000 mocroseconds to yards, multiply both scales by 100. This will then give 164,000 yards as the equivalent distance. It must be remembered that this chart is for ranging where a pulse is transmitted, reflected from the target, and then received. In one microsecond the pulse must travel from the transmitter to the target and back, and hence it will travel 164 yards out and 164 yards back, or a total of 328 yards. Hence the distance to a target is said to be 164 yards per microsecond (delay time between transmission of a pulse and the reception of its echo).

Specifications

Cathode-ray Tube
- Type 5CP-A
- Screen Diameter ..... 5 inches
- Accelerating potential (overall) ..... 4000 volts

Linear-Time-base (for 4-inch sweep length)
- A-sweeps—4500, 1000, 100, 25, 10, 4 μsec
- R-sweeps—25, 10, 4 μsec

Precision Delay Circuit
- 100 μsec range—Any 25, 10, or 4 μsec portion of 100 μsec A-sweep may be examined
- 1000 μsec range—Any 25 or 10 μsec portion of 1000 μsec A-sweep may be examined
- Accuracy—±0.1% of full scale
- Indication—Direct-reading dial calibrated in microseconds

Trigger Sources
- Internal Trigger
  - Output—± 100 volts
  - Rise Time—0.3 μsec
  - Duration—1 μsec
  - Repetition rate—80-400 times/sec on 1000 and 4500 μsec A-sweeps.
    80-2000 times/sec on 100 μsec A sweeps.
- External Trigger
  - Input—±15 volts
  - Rise Rate—±100 volts/μsec for accurate triggering, otherwise ±10 volts/μsec
  - Repetition Rate—0-400 times/sec for 1000 and 4500 μsec scales.
    0-2000 times/sec for 100 μsec scale

Markers
- Fixed
  - Separation—10 and 50 μsec
  - Rise Time—0.25 μsec
  - Duration—1 μsec
  - Accuracy—±0.02%
- Movable
  - Duration—Approximately 25 μsec
  - Start—Coincident with start of R-sweeps (depends on setting of delay dial)

Video Amplifier
- Input Impedance—1 meg, 20 μμf
- Attenuation Ratios—1:1, 3:1, 10:1, 30:1, 100:1
- Deflection Factor—Better than 0.3 v (rms)/inch
- Polarity—Positive signal deflects upward
- Sine-wave Response—Down not more than 3 db at 8 megacycles
  Down not more than 6db at 11 magacycles
- Pulse Response—Sum of rise and fall times of a 1-μsec pulse with rise and fall times of 0.01 μsec does not exceed 0.08 μsec when passed through video amplifier.
  1000-μsec pulse does not change vertical position of base line after pulse by more than 10% of pulse height.

Power Input
- Voltage ..... 115 volts ±10%
- Frequency ..... 60 cps
- Power Consumption ..... 220 watts
- Fuse Protection ..... 2 amperes

Physical Specifications (over-all)
- Height ..... 16¼ in.
- Width ..... 11⅜ in.
- Depth ..... 26 in.
- Weight ..... 104 lb.
- Finish ..... black wrinkle
- Removable panel cover

Catalog No.	Type No.	Description	Code Word
1296	256-D	115 v, 50-60 cps; 5CP 1A Cathode-ray Tube	YALDW
1297	256-D	115 v, 50-60 cps; 5CP 2A Cathode-ray Tube	YALDX
1299	256-D	115 v, 50-60 cps; 5CP 7A Cathode-ray Tube	YALDZ
1300	256-D	115 v, 50-60 cps; 5CP 11A Cathode-ray Tube	YALEA

PRESSURE-TIME CHARACTERISTICS

Although the usefulness of the cathode-ray oscillograph has been generally acknowledged, many potential applications never materialize because of the apparent gap between the electronic industry and other fields.

Readers not already familiar with the Pressuregraph* will welcome this commercially available instrument which is designed for use with a cathode-ray oscillograph, on whose screen a pressure-versus-time characteristic may be presented. The Pressuregraph is an electronic instrument for the measurement and recording of dynamic and static pressures. It is recommended for use wherever static, transient, or periodic pressure phenomena are to be studied; it functions in either gaseous or hydraulic media. The in-

*Manufactured by Electro Products Laboratories, 549 W. Randolph St., Chicago 6, Ill.

strument will produce full-scale deflections for pressures ranging from below atmospheric to over 10,000 psi.

This instrument has been successfully applied to the solution of many problems involving pressure phenomena in gasoline and diesel engines, jet or reaction engines, explosions of gases in pipelines, superchargers and air compressors. It has found particularly wide acceptance in the diesel and gasoline engine field, where its ease of installation and operation make it a very useful tool in the study of intake, exhaust, and firing pressures.

The Pressuregraph employs a system of carrier modulation, wherein a 100-kilocycle carrier is modulated in accordance with the pressure variation. The equipment consists of (1) an electromechanical pick-up, (2) an associated electronic circuit and power supply, and (3) a cathode-ray oscillograph.*

The pick-up consists essentially of a capacitor, one plate of which is fixed, and the other being an interchangeable diaphragm separating the region under study from the atmosphere.

This dynamic capacitor is in series with a 100-kc generator. As the pressure changes, the shape of the diaphragm is altered, causing a change in the value of the capacitive reactance. Thus the 100-kc current in the network is amplitude modulated by the pressure; increasing pressure is accompanied by increasing carrier current and vice versa. The modulated carrier signal is fed to the Pressuregraph unit, where it undergoes certain electronic shaping operations. The output signal from this unit is applied to the vertical deflection system of the cathode-ray oscillograph. The Pressuregraph provides the engineer with qualitative information as to the relative magnitude and time sequence of the individual phases of the pressure phenomenon; wave form, rate of rise, presence of cavity oscillations and other pertinent data are obtainable by visual means.

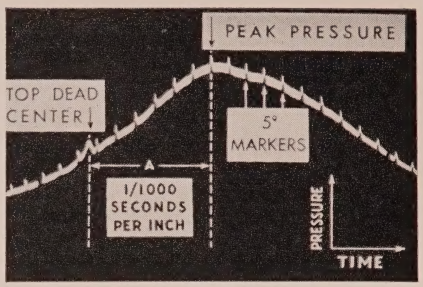
*Du Mont Type 208-B, 247, or 250.

Electro Pressuregraph, accessories, and Du Mont Type 208-B *Cathode-ray Oscillograph — complete instrumentation for the study of pumps and internal combustion engines.*

Whenever quantitative pressure measurements are necessary, the Pressuregraph can be conveniently calibrated with the aid of a source of compressed air and a static pressure gage. Thus it is only required to introduce compressed air at various pressures and to plot a calibration curve of oscillograph deflection versus pressure.

Synchro-Marker — The Synchro-Marker is an electronic device designed to extend and enhance the usefulness of the Pressuregraph. These two instruments plus an oscillograph represent complete instrumentation for the study of pumps and internal combustion engines. The Synchro-Marker performs three important functions:

1) It synchronizes the time-base generator of the cathode-ray oscillograph with the rotation of the engine under study; this makes the trace of the pressure phenomenon being examined appear stationary on the screen. The point in the revolution at which the sweep is tripped can be varied continuously through 360 degrees ***while the engine is in operation.*** This feature, added to the possibility of expanding the width of the trace by means of the horizontal amplifier of the oscillograph, permits convenient and thorough examination of any particular portion of the pressure cycle.



Firing and coasting stroke of a single-cylinder engine showing five-degree markers, spark-coil primary current and spark discharge, also pressure transients.

2) It provides marker signals which appear on the screen with the pressure trace; these sharp pulses relate the instantaneous pressure with crankshaft angle, by appearing every five degrees of rotation, or they relate instantaneous pressure with time by appearing every millisecond.

3) It provides an identification pulse once each revolution. The occurrence of this pulse can be adjusted to coincide with that of top or bottom dead-center, or with that of any other important point in the rotary cycle. Thus the pressure phenomenon can be related in time, or with crankshaft angle, to any selected event in the cycle.

NOTES ON OPERATION OF THE TYPE 281 CATHODE-RAY INDICATOR AT MAXIMUM WRITING RATE

The second-anode power supply of the Type 281 Cathode-ray Indicator is designed to deliver four kilovolts at two milliamperes into its load and to regulate this voltage within ± 2 per cent. Higher currents, however, may be supplied for short intervals of time because of the storage capacity of the filter circuit. These higher currents are a function of both their duration and amplitude. For example, the power supply can deliver four milliamperes for a period of 800 microseconds with a 50 per cent duty cycle or five milliamperes for a period of 400 microseconds for the same duty cycle. The maximum cathode-current rating of the Type 5RP-A series of cathode-ray tubes, which is used in the Type 281 Indicator, is five milliamperes.

It must be kept in mind when using the Type 5RP-A Cathode-ray Tube that the cathode current of five milliamperes cannot be supplied continuously to the electron gun. There are two limitations placed on the maximum continuous current, the average power dissipation in the second anode (seven watts), and the maximum allowable screen current. The permissible screen current varies with the writing speed of the

spot. For slowly moving spots the beam current must be very low in order to prevent screen burning. In no case should a sharply focused spot or line resulting from a high-current beam be allowed to remain stationary on the screen. The electrons in the beam have sufficient energy to penetrate the screen coating and, in a short time, penetrate the glass face of the tube.

As normally supplied, the Type 281 Indicator has a resistor in its cathode circuit to limit the cathode current to a reasonable value and to provide a means of modulating the beam through the cathode in certain applications. In attempting to use the higher beam currents as pointed out above, it is necessary to short out this resistor, thus making it impossible to apply intensity modulating signals to the cathode.

— W. G. Fockler.

PROJECTION SCREENS

The performance of projection equipment, such as the Du Mont Type 247-A (or Type 248-A)—Type 2088 combination, is affected by the type of projection screen employed.* If the number of observers is such that the picture will be viewed from a wide angle, a non-directive screen must be used. However, wide-angle screens disperse light in all directions and must be used in a darkened room.

For projection in a room where unfavorable ambient light conditions exist, a directive screen is desirable.** This type of screen has a surface which is composed of microscopic, spherical, lenticular elements. Such a screen increases the light output by reflecting most of the light in one direction.

Several screens of this type are now on the market. Further information may be obtained from Allen B. Du Mont Laboratories, Inc., Applications Engineering Section, Instrument Division, 1000 Main Ave., Clifton, N. J.

*See: "A New Oscillograph for Recording High-Speed Transients," The Oscillographer, Vol. 8, No. 4, July-August, 1946.

**See Berkley, C.: "Type 2088 Projection Lens," The Oscillographer, Vol. 8, No. 6, pages 2 and 3, November-December, 1946.

RADIOPHON EXECUTIVE VISITS DU MONT

Mons. Paul Fabricant, president of Radiophon of Paris, visited Allen B. Du Mont Laboratories on March 5th. Mons. Fabricant, our French distributor, has represented Du Mont for the last twelve years. During his visit he was further acquainted with new Du Mont instruments.

SYMPOSIUM PRESENTED ON CATHODE-RAY EQUIPMENT AND TECHNIQUES

On Wednesday, April 14, Allen B. Du Mont Laboratories, Inc., Instrument Division, presented a Symposium on Cathode-ray Equipment and Techniques, at the Wardman Park Hotel, Washington, D. C.

The purpose of the Symposium was to acquaint qualified government personnel of the Washington area with the latest advances in the cathode-ray art. Many industrial representatives as well from Washington, D. C., Virginia, Maryland and surrounding states attended.

The Symposium was divided into three sessions, and the various lectures of each session were repeated on the same day. This was necessary to accommodate the overflow attendance of 800 persons.

The latest and most advanced Du Mont equipment was on display at the Symposium to illustrate the techniques and advances in the art described by the speakers. The feature speakers were Dr. P. S. Christaldi, W. A. Knoop, E. G. Nichols, M. G. Scheraga, and A. W. Janes, all of the Du Mont organization.

The important recent development of new display methods in cathode-ray oscillography was definitively treated in a discussion of dual-beam oscillographs and polar-coordinate indicators. Added point was given to this lecture by first-hand demonstrations with the Du Mont Type 279 Dual-beam Cathode-ray Oscillograph and the Type 275-A Cathode-ray Polar-coordinate Indicator.

The latest techniques for the presentation of high-speed phenomena

were the subject of a second lecture. Oscillographic methods for the examination of any part of an extremely complex signal, such as the individual scanning line of a television signal, were discussed; demonstrations for this talk were obtained with the Du Mont Types 280 and 256-D Cathode-ray Oscillographs. In the field of high-voltage oscillography, the present-day trend toward high accelerating potentials was a theme also developed, together with a discussion of the nature of the equipment required to present writing rates in the neighborhood of 400 in/μsec. For this latter theme, illustrative material was available in the Du Mont Types 281 and 286.

A third major development in modern oscillography is the use of photography to obtain permanent oscillograph-records. The most up-to-date information on oscillograph-record cameras was high-lighted by the availability of the Types 271-A and 314 Oscillograph-record Cameras.

It was felt by all concerned that a Symposium of this type extends the specialized knowledge of the cathode-ray art into new fields where it can be utilized to the general advancement of the electronics industry as a whole.

THE SERVICING OF DU MONT INSTRUMENTS

Realizing that accuracy and dependability are the major requirements of an instrument, Du Mont employs every practicable measure to thoroughly test each new instrument for conformance with design requirements, workmanship, and performance.

Despite such precautions, it is inevitable that failures of components will occasionally develop in an instrument that employs many complex circuits and intricate assemblies. Therefore Allen B. Du Mont Laboratories maintains its Instrument Service Department to maintain the quality and performance that are universally associated with all Du Mont oscillographs and auxiliary equipment.

It is the Instrument Service Department that backs our guaranty of quality materials, workmanship, and satisfactory operation for a period of one year (cathode-ray tubes are guaranteed for six months or 1000 hours, whichever first expires). The immediate availability of service facilities, service information, and exact replacement parts is positive assurance that the purchase of a Du Mont instrument is a long-term investment.

We stock replacement components for each instrument for a minimum period of five years after its production has been discontinued. Through this policy we have been fortunate in being able to service some of our earliest instruments, made a dozen years ago. Since Du Mont instruments contain many standard, commercially available components, it will always be possible to secure replacement parts.

In addition to the above-mentioned duties, the activities of the Instrument Service Department guarantee future utility through the practice of this department to modify some instruments when feasible and thereby delay their obsolescence. For example, the usefulness of the Types 247 and 248 Oscillographs may be extended by a conversion which enables the use of the fast-writing, brilliant-trace Type 5RP-A Cathode-ray Tube.

The service findings and reports of this department are of inestimable help to Du Mont engineers during the design of future instruments; refinements are often determined by the performance of previous models.

Du Mont is also able to furnish complete servicing instructions together with necessary replacement parts to those who wish to do their own servicing, and to those who cannot spare their instrument for the time required for a return to the factory.

If facilities for repair are not available, the instrument should be returned to the factory or to an authorized Du Mont service agency. Unnecessary delay may be avoided by first supplying the Instrument

Service Department with the type and serial numbers of the instrument, the application in which the instrument was used, a description of the trouble encountered, together with a written authorization or purchase order to make the necessary repairs.

Such information enables the Instrument Service Department to suggest simple corrective measures which often makes it unnecessary to return the instrument to the factory. In several instances, equipment not in need of repair has been needlessly returned to our factory because the above procedure was not followed.

If repairs are necessary, the Instrument Service Department makes a record of the anticipated service job and it forwards the necessary shipping instructions. Thus the instrument can be immediately identified upon arrival, and prompt attention is assured.

Orders for spare parts should include the part numbers or reference symbols of the required components, as well as the type and serial numbers of the instrument.

All correspondence concerning the repair of instruments and replacement parts should be addressed to Mr. Grover C. Seymour, Instrument Service Department, Allen B. Du Mont Laboratories, Inc., 1000 Main Ave., Clifton, N. J.

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[1] London — monthly.
[2] Paris — annual.
[3] National Association of Broadcast Engineers and Technicians — New York — monthly.
[4] Pittsburgh, Pa. — monthly.
[5] London — quarterly.
[6] Zurich — semi-monthly.
[7] American Institute of Physics, N. Y. — monthly.

A view of the Du Mont booth at the IRE exhibition in the Grand Central Palace during the annual convention of the Institute of Radio Engineers in New York on March 22-25. The Instrument Division displayed cathode-ray instruments developed during the past year. Units which attracted much attention were the Type 279 Dual-beam Cathode-ray Oscillograph, the Type 275-A Cathode-ray Polar coordinate Indicator, the Type 280 Cathode-ray Oscillograph, and the Types 271-A and 314 Oscillograph-record Cameras.

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